Sb_2O_3-Halogenated Copolymer binder flame retardant Finish for Canvas Cloth for tents and tarpaulins

In this article by Dr. D. R. Gupta, Department of Chemistry, University of Roorkee and his associates Dr. J. P. Jain, Km. Abha Saxena and Shri N. K. Saxena of Fire Research Division, CBRI Roorkee, a valuable account of the successful development of an effective fire retardant finish for canvas cloth for tents—unaffected by repeated washings—has been given, together with results demonstrating the synergistic effect of Sb_2O_3 and halogenated copolymer binder.

—Editor

ABSTRACT

A chemical formulation based on antimony oxide and halogenated copolymer binder has been developed to impart flame retardancy to canvas cloth. Various tests namely fire performance, tensile strength, effect of laundering on fire performance and smoke density were carried out with treated canvas cloth to evaluate the effectiveness of the treatment. The results show that this treatment could be used to reduce fire hazards in tents and pandals.

INTRODUCTION

Canvas cloth being cellulosic in nature is considered highly flammable because it is readily ignited and rapidly consumed after ignition.

Since long three main types of flame retardant treatments for cellulosic fibres are in use. (I) Temporary water soluble treatment such as ammonium phosphates and borates for curtains, draperies, mattress stuffings, and the like where contact with water is deemed unlikely[1-3]. (II) Permanent treatment, namely THPC and phospono alkanoic amides for garments, mattress ticking, and interior fabrics where launderings may be required but severe weathering is unlikely[4-6] and (III) Coatings with Sb_2O_3+Chloro Paraffins for outdoor fabrics, especially for military use [7, 8].

In view of the importance of the problem, a chemical formulation based on antimony oxide and vinyl acetate/vinyl chloride copolymer binder was developed to impart flame retardance to canvas cloth. Various evaluation tests were carried out and the results obtained are presented in this communication.

MATERIALS & METHOD

A chemical formulation has been developed for rendering the canvas cloth fire retardant namely solvent suspension containing the following ingredients.

Sl. No.	Name of the Chemical	Nature of the Chemical	Wt. percent
1	Antimony Oxide	Flame inhibiting agent with halogenated copolymer binder	7—15%
2	Halogenated Copolymer binder	Used as a source to provide hydrochloric acid at ignition temperature for synergistic effect and as a binder.	2— 8%
3	Borate Salt	As glow retardant	4— 8%
4	Phosphate Salt	Plasticizer and flame retardant	1— 5%
5	Phthalate salt	Softening Agent	0.01— 2%
6	Ester of carboxylic acid	Solvent	75—88%

Procedure of the fabric Treatment :

A solvent suspension was prepared by mixing the borate salt and finely divided antimony oxide and this mixture was dispersed in a solution obtained by dissolving the halogenated copolymer binder and phosphate salt in an ester or ketonic organic solvent.

The specimens of canvas cloth were treated with the help of knife edge type applicator, dried at room temperature and kept in an oven at 60°C for about half an hour and hot pressed. A chemical retention of 65 to 70% addon (dry basis) was found adequate to render the fabric as effective fire retardant.

TEST METHODS

(a) Fire Performance Test :

The treated samples were tested as per B.S. 3119[9]. The samples of the size 31.75 cm × 5 cm were mounted vertically and a standard flame was applied for the period of 12 seconds and then withdrawn. The fire performance is reported in 'Results and Discussion'.

(b) Effect of laundering :

The durability of the treated fabric on laundering was tested by repeated washings with detergent solution for 30 minutes in each case. The results obtained are given in 'Results and Discussion'.

(c) Breaking Load of untreated and treated Canvas Cloth :

The Breaking load of the untreated and treated samples size 15 cm X 3.5 cm before and after repeated washings was determined by using tensometer Model type W (Monsanto London). The results obtained are shown in 'Results and Discussion'.

(d) Smoke Density Test :

The specimens of the size 7.6 cm x 7.6 cm of untreated and treated canvas cloth were tested in a smoke density chamber as per ASTM E 662-79[10].

The specimen of the size 76.2 mm x 76.2 mm is mounted within a holder which exposes an area of 65.1 mm x 65.1 mm. The specimen is facing the electrically heated radiant energy source which is mounted within an insulated ceramic tube and positioned so as to produce an irradiance level of 2.5 W/cm² averaged over the central 38.1 mm diameter area of the vertically mounted specimen. A photometric system with a vertical light path is used to measure the varying light transmission as smoke accumulates. The light transmittance measurements are used to calculate the specific optical density of the smoke generated during the time period to reach the maximum value.

RESULTS AND DISCUSSION

The results of the fire performance test of untreated and treated specimens are recorded in Table I.

It is evident from the Table I and Figure 1 that in the case of untreated samples, flame starts travelling vertically and the sample is completely burnt up in 20 seconds. The treated samples when exposed to flame show no flame spread and after glow of only 8-18 seconds at 30-60% retention (dry addon), while at the retention of 65-70% the specimens show no flame spread and glow of only 2 seconds. The samples remain unaffected except for the charred portion. Thus the 70% retention is most adequate for fire retardance because the glow time 2 seconds remains c nstant upto 94% Retention.

The results of the fire performance test after repeated washings with detergent solution are pres - nted in Table 2.

The treated samples resist the washings reasonably well and the flame retardance does not decrease appreciably even after 11 washings as shown in Table 2 and figure 2. However, the treated samples were found to be in the limit of standard vertical tests even after several washings.

The results of the tensile strength of untreated and treated samples both in warp and weft directions before and after repeated washings are presented in Table 3. It is clear from Table 3 that there is an increase of 10-20% in tensile strength of the treated samples and this increase in the tensile strength is not considerably lost even after 11 washings with detergent solution.

The results obtained from the smoke density chamber test in case of both the untreated and treated samples are shown in Figure 3. It is clear from the graph that the smoke is increased in the case of treated samples in comparsion to the untreated samples. The smoke obscuration index (SOI) for the untreated and treated samples are found as 3.015 and 19.28 respectively.

The reaction mechanism of the chemical treatment is based on the synergistic effect of Sb_2O_3 and halogenated copolymer binder[6]. When Sb_2O_3 is associated with the halogenated copolymer binder, an excellent flame retardance is obtained. The reactions taking place during the process are given below :

$$Sb_2O_3 + 6HCl \longrightarrow 2\,SbCl_3 + 3H_2O$$

$$Sb_2O_3 + 2HCl \longrightarrow 2SbOCl + H_2O$$

$$5\,SbOCl \longrightarrow SbCl_3 + Sb_4O_5Cl_2$$

$$3\,Sb_4O_5Cl_2 \longrightarrow 2SbCl_3 + 5\,Sb_2O_3$$

$SbCl_3$ is strongly acidic and functions as a dehydrating catalyst as well as a flame quencher.

TABLE 1

Fire Performance Test of Untreated and Treated Fabric.

Add on % (dry basis)	Time of exposure Sec.	Time of flame spread Sec.	Time of after glow Sec.	Char. length Cm.	Char. Area Cm^2	Remarks
Untreated	12	Flame spread continued				Burnt entire length
Treated						
34.3	12	0	18	5.5	16	Self-Extinguished
39.0	12	0	16	5.0	14.4	"
40.9	12	0	14	4.8	13.5	"
45.5	12	0	13	4.0	12.0	"
54.8	12	0	12	4.0	10.5	"

Add on % (dry basis)	Time of exposure Sec.	Time of flame spread Sec.	Time of after glow Sec.	Char. length Cm.	Char. Area Cm^2	Remarks
55.8	12	0	10	4.0	7.5	Self-Extinguis
62.0	12	0	8	4.0	6.0	"
64.4	12	0	4	4.0	5.0	"
68.6	12	0	3	4.0	4.5	"
70.2	12	0	2	3.5	4	"
74.7	12	0	2	3.0	4	"
82.8	12	0	2	2.0	3.5	"
87.8	12	0	2	2.0	3	"
94.6	12	0	2	2.0	2.2	"

TABLE 2

Effect of washings on Char area and glow Time

No. of Washings	Time of exposure Sec.	Flaming Time Sec.	Glow Time Sec.	Char length cm	Char Area cm^2
One	12	0	2	4.0	4.0
Two	12	0	2	4.0	4.0
Three	12	0	3	4.5	4.2
Four	12	0	4	4.8	4.5
Five	12	0	6	5.0	4.8
Six	12	0	6	5.2	4.8
Seven	12	0	7	5.5	5.0
Eight	12	0	9	5.8	5.2
Nine	12	0	11	6.0	5.4
Ten	12	0	12	6.2	5.5
Eleven	12	0	14	6.2	6.0

TABLE 3

Breaking load of Untreated and Treated Canvas Cloth

Before Washing				After Washing				
Untreated		Treated			Untreated		Treated	
Warp	Weft	Warp	Weft	No. of Washing	Warp	Weft	Warp	Weft
50	30	61	45	1	50	30	60	50
50	30	60	45	3	48	29	58.6	49
55	30	60	48	5	47	28	57.0	48.2
50	31	61	46	7	45	26	55.5	46.2
56	32	58	42	9	44.5	25	54.0	45.5
				11	43.5	24.2	53.0	44
52.2	30.6	60	45.2		46.3	27.0	56.3	47.1

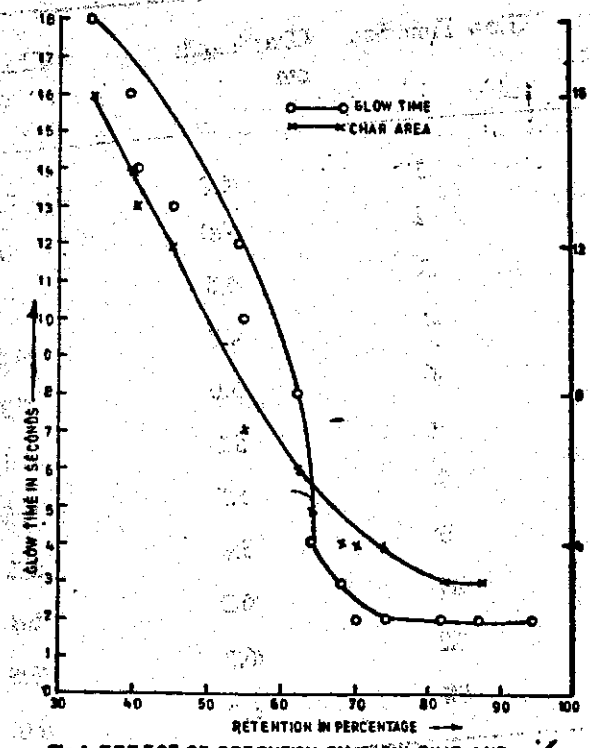

Fig 1 EFFECT OF RETENTION ON GLOW TIME AND CHAR AREA

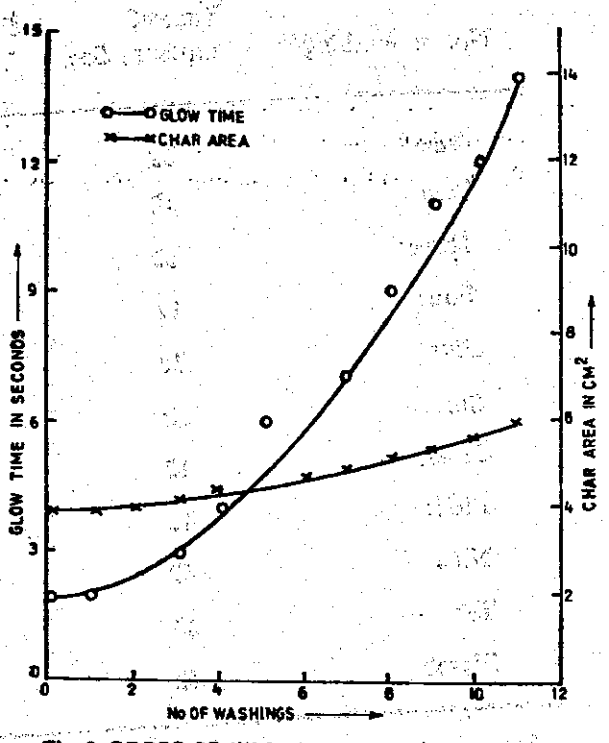

Fig 2 EFFET OF WASHINGS ON GLOW TIME CHAR AREA

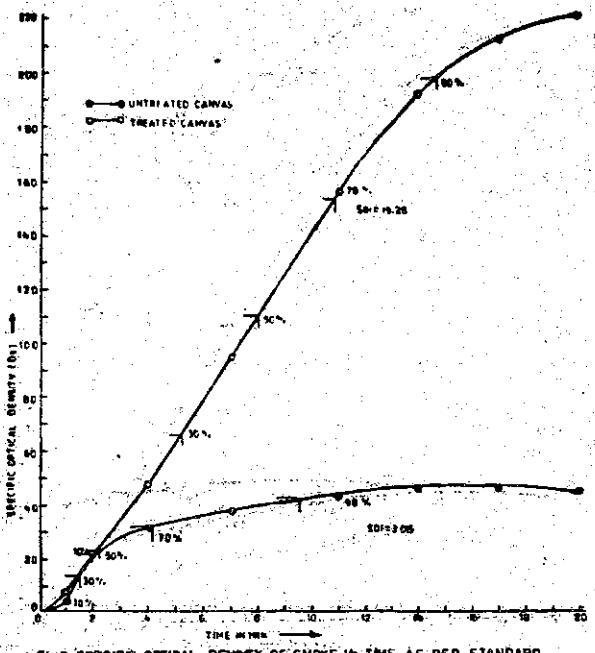

Fig 3 SPECIFIC OPTICAL DENSITY OF SMOKE Vs TIME AS PER STANDARD ASTM E 662-79

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